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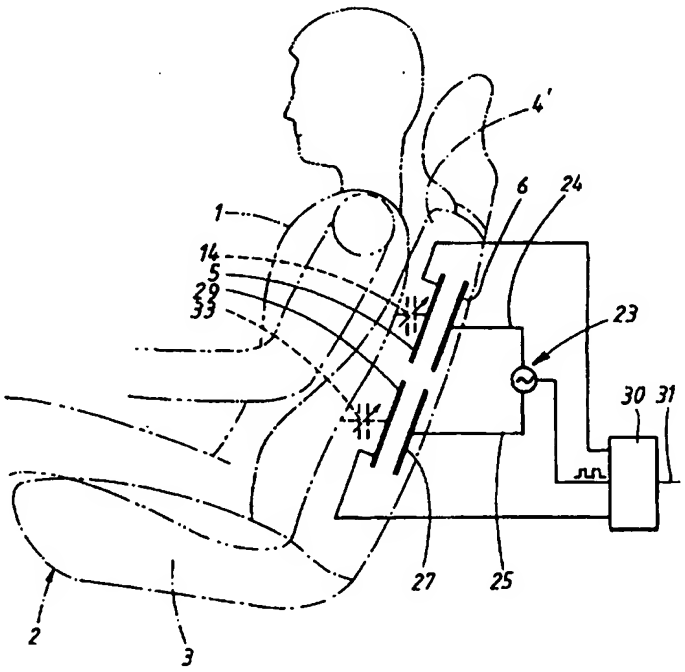
(54) Title: DEVICE FOR SENSING PRESENCE OF AN ELECTRICALLY CONDUCTING OBJECT

(57) Abstract

Device for detecting the presence of an electrically conducting object (1) in a predetermined area. There is a device (23) for emitting a driving signal in the shape of an alternating current. There is also a capacitive sensor element (5) and a means (30) to detect the change in capacitance between said sensor element and the surroundings which is caused by present object or absent object. A second capacitive element is formed by a second sensor element (29) which is driven by a second driving signal (25) which is in counter-phase relative to the first driving signal (24). Alternatively, the second capacitive element can be in the shape of a screening element which load-wise is isolated from the sensor element but maintains essentially the same potential as it.



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TITLE:

DEVICE FOR SENSING PRESENCE OF AN ELECTRICALLY CONDUCTING OBJECT

TECHNICAL FIELD:

The present invention relates to an arrangement for detecting the presence of electrically conducting objects in a certain area. An arrangement emits a driving signal in the shape of an alternating current, to drive a capacitive sensor element. An arrangement detects the difference in capacitance which is present between the sensor element and surrounding objects, both in the presence and absence of objects.

BACKGROUND OF THE INVENTION:

There are, within different fields, a need to detect the presence or absence of objects. There is a large amount of various technical solutions used, and the choice of principle in many cases depends on the intended application. Examples of different solutions are photocells, mechanically switchable switches and capacitive sensor systems. The principle of the latter technology is well known, and well suitable for i.a. the detection of people in a seat in a vehicle, in order to activate or deactivate various functions, e.g. heating elements in the seat or air-bags. Air-bags for passengers have caused severe injuries when activated, when e.g. a backwards facing child-seat is used, or when passengers who e.g. have not used a seat-belt have leaned forward at the moment of activation.

Previously known capacitive systems have, however, not fulfilled the high demands for reliability. One difficulty has been to, with high reliability, distinguish the capacitance caused by the present of measuring objects from the other capacitances in a vehicle. This is due to the fact that the capacitance between the capacitive sensor

element and the other objects in a vehicle (except for people) can be large and/or vary greatly. The frame, for example, is in practically all vehicle seats of metal, and has a varying distance to the capacitive sensor element in the seat. Since the capacitance from the sensor element to the frame is approximately equal to the capacitance to a person, this causes a large spread in the detection distance.

The extremities of a passenger in the rear seat can, when driving, be pressed into the back-rest of the seat from behind, or into the seat from below. These extremities are electrically conducting, and in the same way as has been described above regarding the frame, cause a large spread in the detection distance to the person in front.

TECHNICAL SOLUTION:

The object of the present invention is to reduce the influence of larger capacitances, and thereby to increase the reliability of capacitive detection devices.

The said object is achieved by means of a detection device according to the present invention, which is characterized in that a second capacitive element is arranged to be driven in counter-phase relative to said first driving signal.

According to an alternative embodiment, the invention is characterized in that a second capacitive element is formed by a screening element, which load-wise is isolated from said sensor plate but maintains essentially the same potential as it.

DESCRIPTION OF THE FIGURES:

The invention will be described in the following in greater detail using examples of embodiments, and with reference to the attached drawings, in which:

Fig. 1 schematically shows a first example of an embodiment of a detection device according to the invention,

Fig. 2 schematically shows a second example of an embodiment,

Fig. 3 schematically shows a third example of an embodiment, and

Fig. 4 shows a perspective view of an example of the location of the capacitive elements in the example shown in Fig. 3.

PREFERRED EMBODIMENTS:

All of the examples of embodiments show a very essential application for the detection device according to the invention, which is the detection of absence or presence of a person with regard to a defined detection area in the seat of a vehicle. The purpose of the detection is, for example, to deactivate an air-bag when absence is detected with regard to the detection area, so that the air-bag is not triggered unnecessarily, or causes injuries due to the fact that a child-seat is being used, or that the person is in an unsuitable position in the seat of the vehicle. For this purpose, the detection area is suitably chosen to comprise a limited part of the area of the vehicle seat, so that detected presence does not mean that a person is in the seat, instead detection of presence will require that the person sits essentially reclined in the seat, or at a certain maximal distance from the back-rest. Thus, this

means that when a child-seat is being used in the seat, with a child sitting in the seat, absence is detected. In the figures, lines and dots show a person 1 in a correct position in a vehicle seat 2 which is also indicated with lines and dots, i.e. the person is sitting on the seat 3 and is essentially reclined towards the back-rest 4´. The person is thus in the detection area of the detection device, which can for example have a vertical extension which starts a distance from the lower end of the back-rest, and extends a few decimeter upwards, and extends in the direction towards the back of the person a distance of one or a few decimeters in front of the back-rest.

Fig. 1 shows a first example of an embodiment of a detection device 4 according to the invention, in an embodiment with a so-called double-system, which does not need a reference point such as the chassis of the car or some other electrically conducing surface with a relatively large capacitance between it and the person or the chassis. The device according to Fig. 1 is provided with an arrangement 23 to emit two separate driving signals 24, 25 to one driving plate 6, 27 each, with the two driving signals being at counter-phase relative to each other. The driving plates are arranged to drive one sensor plate 5, 29 each, wherein both the driving plates and the sensor plates are arranged in the back-rest in the example shown. A corresponding system can alternatively, or as a complement be arranged in the seat 3 of the vehicle seat. Due to the double-system, symmetry is obtained in the system without the need of a reference point. The two sensor plates 5, 29 are connected to the voltage detection device 30, which is arranged to emit a signal 31 depending on whether a person is present or absent relative to the detection area. The voltage detected in the detector 30 varies depending on the variable capacitance 14, 33 between the sensor plates 5, 29 and the person 1. The capacitances 14, 33 between the

sensor plates 5, 29 and the surroundings thus varies depending on whether a person is present, i.e. is sitting correctly in the chair or not. Absence can thus be indicated when a person is in a "wrong" position with risk for injuries, for example leaning forwards, or when, for example, a child-seat is being used. The double-system can also be designed using only one sensor plate 5/29, in which case the detector 30 only receives one signal in. Due to the counter-phase signal the person does not receive an alternating currency signal, for which reason his contact with the chassis does not influence the system.

Fig. 2 shows a modified embodiment of the example from Fig. 1, in which the principle with a double-system is used, but in which the driving plates have been replaced with screening plates 34, 35, which are arranged in essentially the same way as the driving plates, but in which the two driving signals from the arrangement 23 which emits driving signals 24, 25 directly drive the sensor plates 28, 29. The screening plates 34, 35 are driven with essentially the same alternating voltage as the sensor plates, via a so-called buffer 36, 37, which load-wise isolates the screening plates from the sensor plates but sees to it that they maintain essentially the same alternating voltage, so that only a small alternating current passes between the sensor plates and a corresponding screening plate. This means that the capacitance between a sensor plate 28, 29 and its corresponding screening plate 34, 35 only to a very small extent influences the sensor plates. Thus, these will essentially detect capacitances in the opposite direction, i.e. towards the front side of the vehicle seat, where the person is sitting who represents the variable capacitance, symbolised with 38, 39. The electronic buffer 36, 37 must also have the ability to give the screening plates 34, 35 the same alternating voltage as the sensor plate, or at least essentially the same voltage, even when the

capacitance between the screening plate and surrounding objects varies. The detector device 30 for example comprises parts of a bridge connection, while the capacitance between the sensor plates 28, 29 and the person 1 are elements in the bridge connection. The numeral 40 denotes a synchronization signal for the synchronization of the detector, whereby interfering signals of another frequency than the frequency of the system are suppressed.

Fig. 3 shows a third example of an embodiment of the detection device according to the invention, which comprises another kind of capacitive element 41, a so-called bias plate, which is driven by a driving signal 42 which is inverted, i.e. in counter-phase relative to the driving signal which drives the sensor plate 28. This bias plate 41 can be combined with any other capacitive measuring system, i.e. a single system with a screening plate or a driving plate, or a double-system with screening plates and driving plates, alternatively in combination with previously known systems. The embodiment of Fig. 3 shows a combination of a directly driven sensor plate 28, a screening plate 34 driven with a buffer 36, and the bias plate 41. In similarity with the double-system of Fig. 2, the sensor plate 28 is fed with a driving signal 24 which is an alternating current from a device 43 for the generation of alternating voltage, while the driving plate 6 is fed with an alternating current with essentially the same driving voltage, but via the buffer 36. The bias plate 41 is connected to the device for generating voltage 43 via an inverter 44 which to the bias plate emits an inverted driving signal, i.e. in counter-phase. The bias plate 41 is preferably mechanically so arranged that it has the smallest possible capacitance with the sensor plate 28, and thus has the smallest possible surface towards the sensor plate. The plates are in Fig. 3 shown in a perspective view to indicate an example of the mechanical positions of the

plates. In the example shown the, sensor plate 28 and the bias plate 41 are in essentially the same plane, and the bias plate at least partially surrounds the sensor plate in this plane. In the example shown, the bias plate 41 for this reason is essentially U-shaped and partially surrounds an area in which the sensor plate is arranged. Alternatively, the bias plate can be ring-shaped and surround an area in which the sensor plate is arranged. The screening plate 34 is in both cases directly in front of the sensor plate, and has essentially the same extension as the sensor plate. By means of a detector 30, the voltage over the sensor plate 28 and the screening plate 34 is detected, and a comparison is made with a reference value and a signal 45 is emitted depending on whether a person 1 is within the detection area in front of the back-rest of the seat or not.

By means of the bias plate 41 which thus serves as a driving plate, an essentially doubled voltage to the voltage detector 44 is obtained relative to a system without a bias plate, and thus a reduced sensitivity to interferences and an increased reliability in operation.

The mechanical arrangement of the electronics apart from the capacitive plates is not described in greater detail. For practical reasons, the electronics is advantageously arranged for example underneath the seat of the vehicle. In order to minimize interfering capacitances in the feeder circuits to the capacitive elements, a shielded feeder cable is suitably used. Advantageously, the shield of the cable can be connected to the capacitive element which serves as a screen or driving surface.

The invention is not limited to the examples of embodiments which have been described above, and shown in the drawings, but can be varied in different ways within the scope of the

appended claims. For example, the capacitive elements can be arranged in different places and in different numbers in the seat of the vehicle. The capacitive elements can also be arranged in connection to an air-bag in order to, from the position of the air-bag, detect presence or absence with reference to a detection area. The detection can also relate to electrically conducting objects other than people, seats for children can, for example, be equipped with an electrically conducting element, for example a foil in the back-rest, in order to deactivate a detection device according to the invention which has been placed in connection to the air-bag. The detection device can be used in entirely different fields than in vehicles. The detection can for example be used within the manufacturing industry to detect absence or presence relative to a detection area.

CLAIMS:

1. Device for detecting the presence of an electrically conducting object (1) in a predetermined area, which comprises an arrangement (23/43) to emit a driving signal in the shape of an alternating voltage, at least one capacitive sensor element (5/28, 29), and a means (30) to detect the difference in capacitance between said sensor elements and the object, respectively the surrounding objects, which occurs in the case of present object and the case of absent object, in which at least one second capacitive element (6, 27/34/41) is arranged in connection to said sensor element, and the device for emitting said driving signal is connected to said second capacitive element with said detection device arranged to detect a change in potential of the sensor element and thus a change in capacitance between the sensor element and its surroundings caused by the absence or presence of the object, c h a r a c t e r i z e d i n that said capacitive element (6, 27/34/41) is arranged to be driven by a second driving signal (25) which is in counter-phase relative to said first driving signal (24).

2. Device according to claim 1, c h a r a c t e r i z e d i n that said second capacitive element is in the shape of a driving element (6) which is arranged on one side of said sensor element (5/28, 29), whereby the detection area is limited to an area which is on the other side of the sensor element, and where the driving element is directly driven by said driving signal, and the sensor element obtains its voltage feed by a capacitive coupling with said driving elements and forms a capacitive voltage splitter for the driving signal, with the split varying, depending on whether the object is present or not.

3. Device according to claim 1,
c h a r a c t e r i z e d i n that said second capacitive element is in the shape of a bias plate (41) arranged to have a low capacitance relative to said sensor plate (28).

4. Device according to claim 3,
c h a r a c t e r i z e d i n that the bias plate (41) is arranged in essentially the same plane as the sensor plate (28).

5. Device for detecting the presence of an electrically conducting object (1) in a predetermined area, comprising a means (23) to emit a driving signal in the shape of an alternating voltage, at least one capacitive sensor element (5, 29) and a means (23) to detect the difference in capacitance between said sensor element and the object, respectively the surrounding objects, which is caused by the presence of the object and the absence of the object, in which at least one second capacitive element (6, 27, 34) is arranged in connection to said sensor element, and the device in order to emit said driving signal is connected to both said sensor element and said second capacitive element, in which said detection device is arranged to detect a change in potential of the sensor element, and in which said second capacitive element is in the shape of a screening element (6, 27) which is arranged on one side of said sensor element, whereby the detection area is limited to an area which is on the other side of the sensor element, and in which the sensor element receives its voltage feed by capacitive coupling with said driving element and forms a capacitive voltage splitter for the driving signal, the split of which is changed depending on whether the object is present or not,
c h a r a c t e r i z e d i n that said screening element (34, 35) load-wise is isolated from said sensor plate (5, 29) but maintains essentially the same potential as it.

6. A device according to any of the previous claims, c h a r a c t e r i z e d i n that said capacitive element (5, 6/26, 27, 28, 29/34, 35/41) are arranged in a vehicle in order to detect the presence of said object in an area adjacent to a vehicle seat.

7. Device according to claim 6, c h a r a c t e r i z e d i n that said device is arranged to, when said object is present, deactivate the triggering mechanism of an inflatable air-bag.

8. Device according to claim 6, c h a r a c t e r i z e d i n that said capacitive elements (5, 6/26, 27, 28, 29/34, 35/41) are arranged in said vehicle seat.

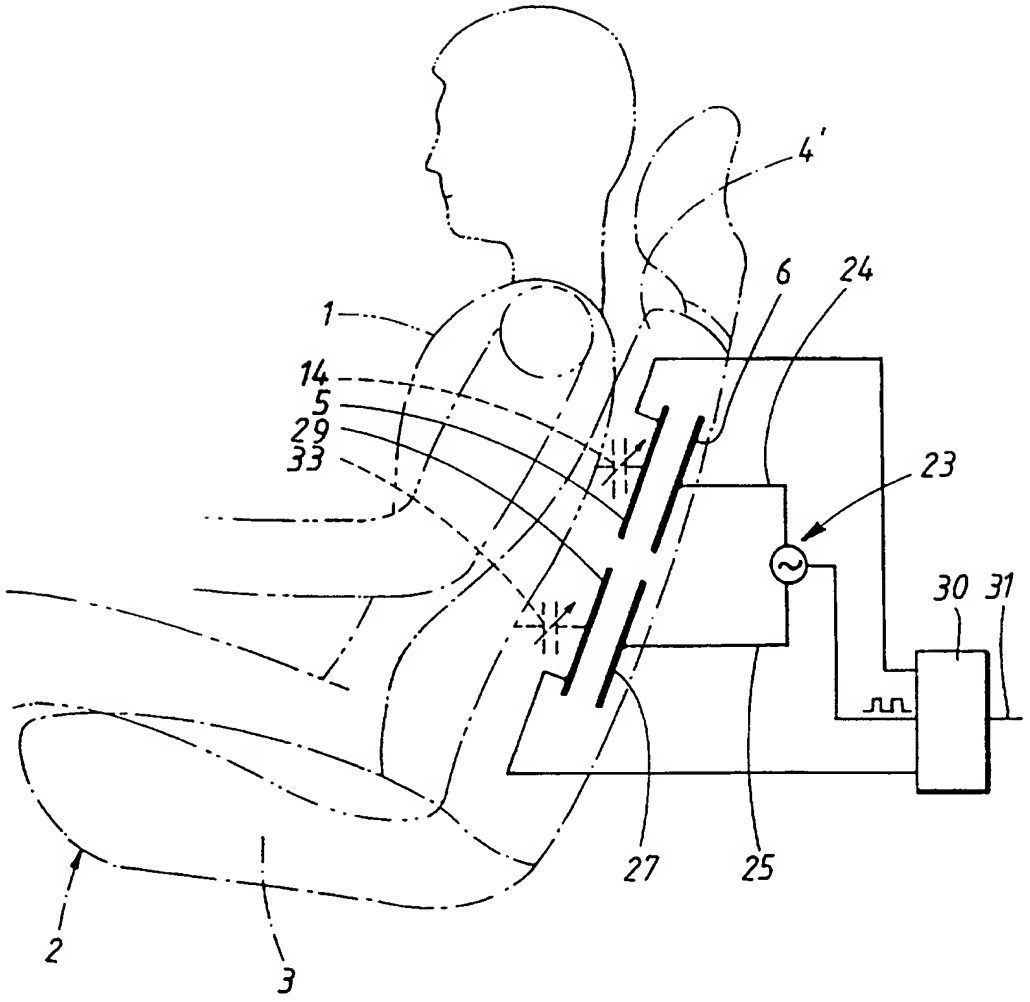

FIG.1

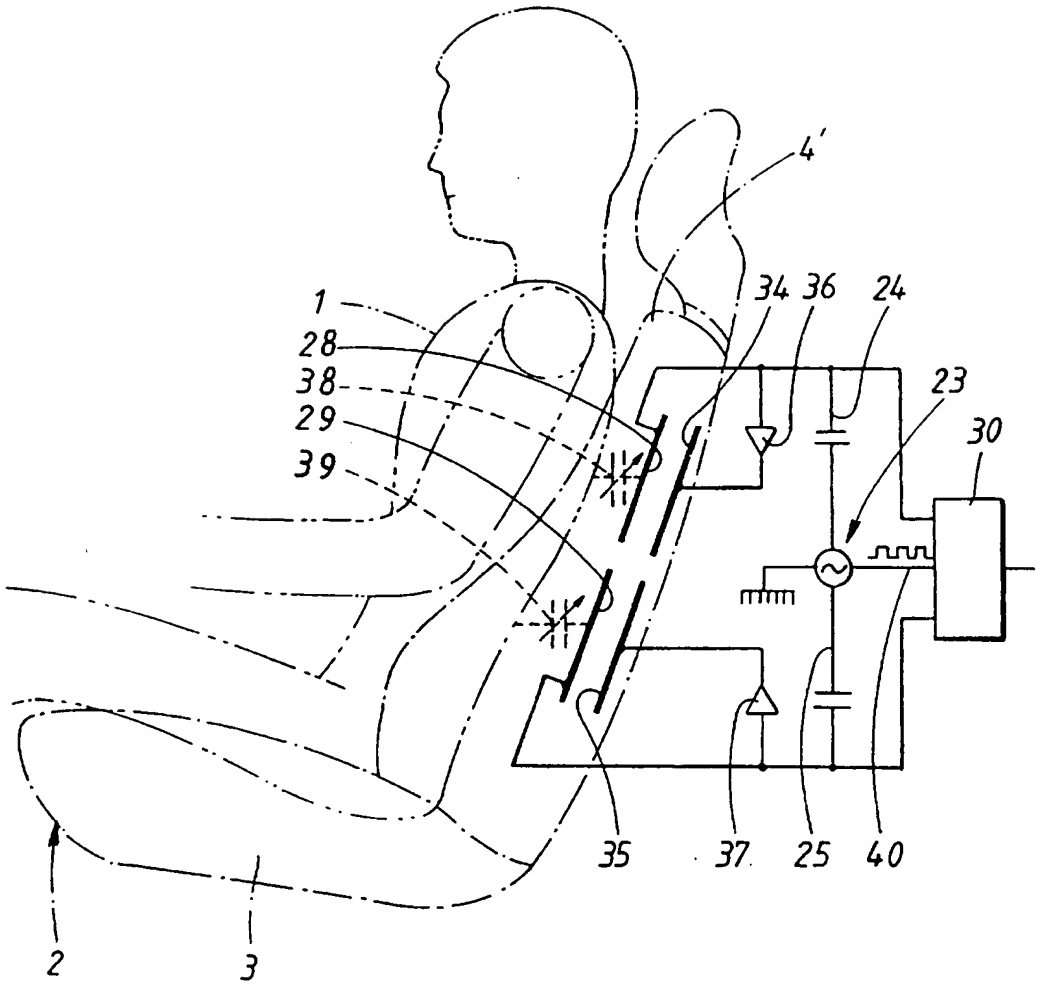

FIG.2

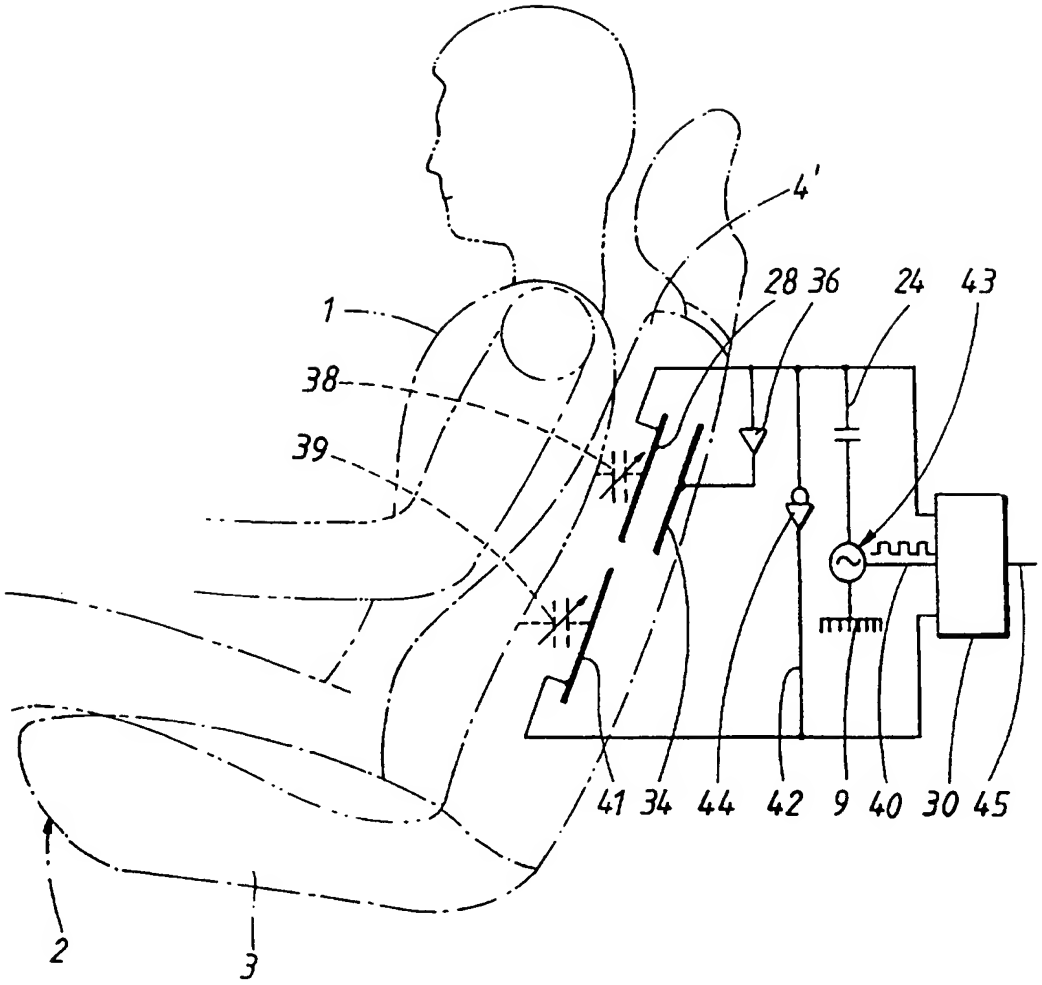

FIG. 3

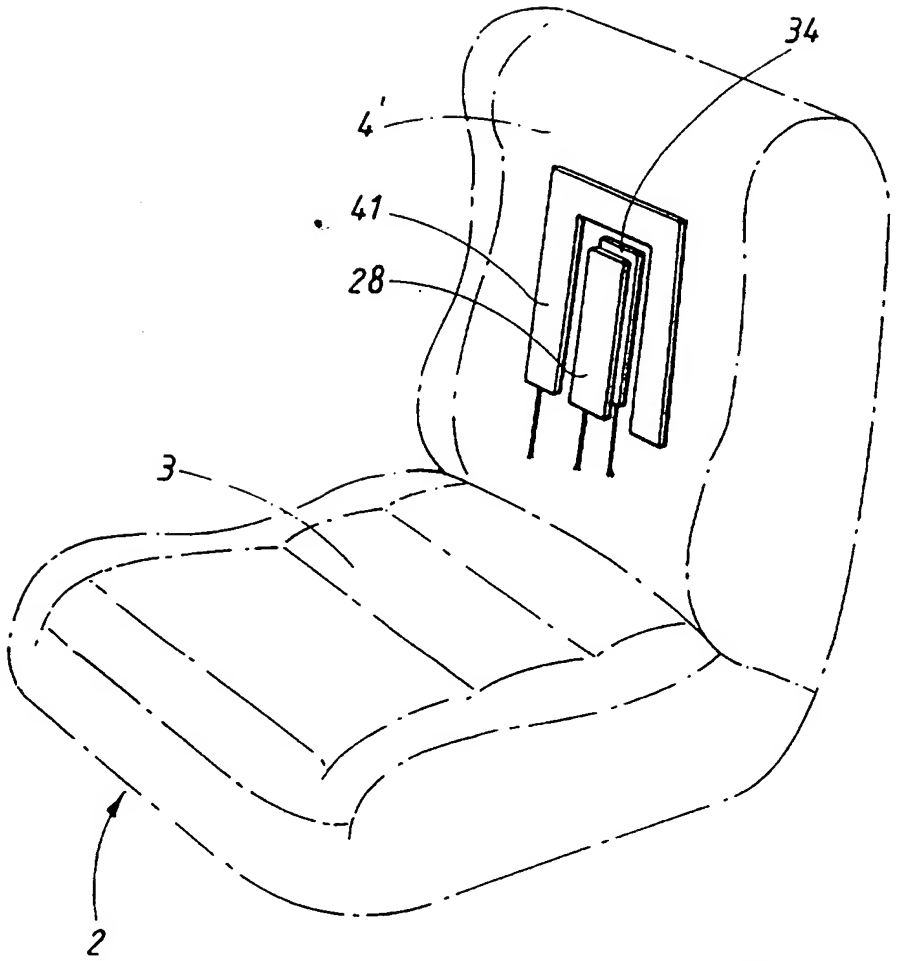

FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00180

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01V 3/08, H03K 17/955, G08B 13/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B60R, G01V, G08B, H03K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	SE 9402673-9 A (SCANDMEC AB), 11 February 1996 (11.02.96), see the whole document --	5-8
X	EP 518836 A1 (THE GOVERMENT OF THE UNITED STATES OF AMERICA AS REPRESENTED BY THE ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINIS.,NASA), 16 December 1992 (16.12.92), column 3, line 30 - line 49, abstract	5
Y	--	6-8
X	US 5373245 A (JOHN M.VRANISH), 13 December 1994 (13.12.94), column 4, line 54 - column 5, line 60	5
Y	--	6-8

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 1996	22 -10- 1996
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00180

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5442347 A (JOHN M. VRANISH), 15 August 1995 (15.08.95), column 2, line 51 - column 3, line 38	5
Y	--	6-8
Y	US 3764861 A (STEPHEN J. ORRIS), 9 October 1973 (09.10.73), column 2, line 37 - column 3, line 3; column 4, line 13 - line 35	6-8
	--	
A	WO 86/02506 A (MEMCO-MED LIMITED), 24 April 1986 (24.04.86), page 2, line 34 - page 3, line 26; page 6, line 7 - line 29	5-8
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INTERNATIONAL SEARCH REPORT

International application No.
PCT /SE96/00180

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Claims 1-4 have been found unsearchable,while according to the characterising part of claim 1 the capacitive element (6,27/34/41) is driven by a second signal,which is in anti-phase to a first signal. This is inconsistent with what is stated in the preamble of claim 1,about the capacitive element being driven by the first signal. The resultant of one signal in phase and one in anti-phase to the same capacitive element is zero.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/10/96

International application No.
PCT/SE 96/00180

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
SE-A- 9402673-9	11/02/96	NONE	
EP-A1- 518836	16/12/92	NONE	
US-A- 5373245	13/12/94	NONE	
US-A- 5442347	15/08/95	NONE	
US-A- 3764861	09/10/73	NONE	
WO-A- 86/02506	24/04/86	NONE	